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Report on the use of computers in assigning over 6,000 students to 1,900 course sections according to a balanced daily study load, with accommodations for athletic activities, work, and extracurricular requirements. Describes general objectives of the process and advantages of the system for students, faculty, and administration.

Copies of the report may be obtained as long as the supply lasts from the Office of Institutional Studies, University of Massachusetts, Amherst, Mass.

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EXPERIENCE AT THE

UNIVERSITY OF MASSACHUSETTS

H. HILLS SKILLINGS

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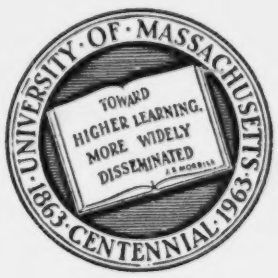

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COMPUTER CLASS SCHEDULING:
EXPERIENCE AT THE UNIVERSITY OF MASSACHUSETTS

H. HILLS SKILLINGS
Assistant Professor of Mathematics
and
University Scheduling Officer

Office of Institutional Studies
Information Series - Number 5
December 1962

Additional copies of this report may be obtained from the
Office of Institutional Studies, University of Massachusetts,
Amherst

FOREWORD

The Office of Institutional Studies is pleased to make available on behalf of the University of Massachusetts this paper on class scheduling accomplished with the aid of electronic computers. At conferences of educational administrators, in workshops on institutional research, and among informal gatherings of academicians, the interest and excitement in this new facet of university operations and procedures has been frequently noted. Thus a belief that others are interested in, and might benefit from, our experiences in this process at the University of Massachusetts has led to the publication of this work.

Originally following the pioneer work of Purdue University in developing automated procedures for handling the computation and assignment work of scheduling, Professor H. Hills Skillings worked in cooperation with the IBM Corporation to break ground in new directions towards this same goal for the University of Massachusetts. The acquisition of our own IBM 1401 computer, plus access to the research facilities of the Massachusetts Institute of Technology's Computation Center, made possible the successful accomplishment of this initial phase of our program—the effective assignment of thousands of student schedules through computer programming.

The class scheduling project utilized the IBM 1401 for preparatory work and the IBM 7090 for the final computation and assignment of class sections. The 7090 class scheduling program was developed by the IBM Corporation University Program in cooperation with the University of Massachusetts. It was based on a program originally developed by Purdue University and IBM in 1960. Copies of the program, including listings and operating instructions, may be obtained from IBM Corporation, Room 26-147, 77 Massachusetts Avenue, Cambridge 39, Massachusetts.

As Professor Skillings indicates in this report, the success of this initial phase has opened up new vistas and opportunities for making our educational process more efficient and more effective. Through his continuing efforts and the efforts of others working in this field, the mastery of man over machine makes possible the release of greater energies and resources for the central objective of education—the mastery of man over himself.

Leo F. Redfern, Director
Office of Institutional Studies

Amherst
December 1962

COMPUTER CLASS SCHEDULING:

EXPERIENCE OF THE UNIVERSITY OF MASSACHUSETTS

In determining what subjects will be offered and at what times the classes will be scheduled, the University of Massachusetts is guided by the following general objectives:

1. to present those subjects meeting at those times which will best serve the needs of the students,
2. to make the most effective use of its faculty,
3. to provide a maximum use of its physical facilities by the hour, by the day and by the week,
4. to assure an economical and efficient operation, and
5. to develop continuing data for use in projecting personnel and building needs.

A few statistics may dramatize the complexities of the problem encountered in the pursuit of these objectives. Discussing solely the programs for the undergraduate four-year students at the University in 1962-63, there are 6200 students enrolled in 1900 different sections of 700 different courses. These classes are conducted by 500 faculty members in 500 classrooms, laboratories, seminar rooms and auditoriums. All of these elements, faculty, students and physical facilities, must be coordinated to the optimum benefit of each component. And this must also be coordinated with programs for 900 students in the Graduate School and 450 students in the Stockbridge School of Agriculture in courses not included above but using the same faculty and same academic facilities.

While experience in previous years provides an appreciable start in developing the schedule for a particular semester, there are many factors which must be evaluated but which cannot be known until very shortly before the semester begins. For example, while the University has a core curriculum which defines certain general areas of study which must be covered by all students, the individual selection of courses which meets these requirements has tremendous latitude. An entering freshman planning to major in liberal arts has more than 1000 possibilities from which to select his program.

Because freshmen do not select their courses until they attend a counselling session, conducted by the Counselling and Guidance Office for relatively small groups (300 to 400) throughout the summer, final demands on the various course offerings cannot be determined until less than two weeks prior to the first classes of the semester. Upper classmen make an initial selection of the fall courses at Counselling Day in the preceding May. However, during the summer many find it desirable, for valid reasons, to change

their elections. The full extent of such changes is not known until immediately prior to the first classes of the semester. Thus, for both freshmen and upper classmen, final course enrollment demands cannot be established with any dependable accuracy more than two weeks at most before school begins. Consequently, last minute adjustments must be made in course offerings or in the number of sections for a certain course in order to optimize the use of faculty and space.

Hand scheduling methods require that student schedules be developed far in advance of the final determination of course enrollments. The time required to adjust student schedules by hand precludes accommodating these last minute adjustments with the result that they either are not made or they are made after classes begin. The first alternative results in wasted faculty effort and inefficient space utilization. The second alternative adds needless confusion to the beginning of the semester and delays the commencement of effective instruction.

Computer scheduling methods can accommodate the majority of the adjustments necessary when final enrollments can be determined with reasonable accuracy. This is possible because the speed of the computer permits delay of scheduling *any* student until the needs of essentially *all* students are known and until departments have been able to determine the necessary adjustments in their offerings.

A discussion of computer scheduling is most easily approached by separating the subject into three general categories: What is computer scheduling, how does it work, and what are its advantages?

WHAT IS COMPUTER SCHEDULING?

Very briefly, computer scheduling is the use of electronic computer equipment to accomplish the assignment of students to classes. In this assignment, several factors are "considered" by the computer. It strives to develop a balanced daily study load for the student, to assure that he has an hour free for lunch, that his requests for time available for athletics, work and other extracurricular activities (when reasonable) are accommodated, to provide for a student's request for a particular section assignment when such is warranted, and to produce sections of sizes consistent with departmental wishes.

All of these factors were present when schedules were developed by hand, but the results of individual efforts produced more confusion and frustration than beneficial results. The variety of combinations possible made it impractical for the human to evaluate them all and to select that which

most nearly achieved the desired results. In one of the test runs during the development of this project, the computer tried 30,000 different combinations of selections before developing a final schedule for a freshman engineering major. The average number of tries per student is about 30.

HOW DOES COMPUTER SCHEDULING WORK?

In outline form, the procedure for scheduling is as follows:

(1) During Counselling Day the student, in consultation with his adviser, selects the courses which the student is to take in the following semester. Counselling Day for the fall semester is in May, and in December for the spring semester.

(2) Next, three types of input information are prepared: (a) the computer program (or "directions"); (b) the student-request information; and (c) the course-and-section information.

(a) The computer program consists basically of a series of coded instructions that are electronically translated by the computer into "directions" telling it how to proceed with adding and subtracting selected values in the proper sequence. Depending upon the computer available, there are various program "languages" which can be used, called by such technical names as FORTRAN, COBOL, and GOTRAN. The University of Massachusetts class scheduling program is done through FORTRAN.

Computer manufacturers can provide technical advice and instruction manuals (as well as a broad array of standard "programs") to institutions desiring this service. Commercial computing services also provide such technical information and advice, as well as "renting time" on their computers to clients. Learning the basic elements of a computer "language" is not too difficult, given a little time and sufficient motivation. Knowledge of advanced mathematics is not required, though it is helpful of course. The actual programming of a complex problem, such as class scheduling, should be done by an expert programmer, however. Skilled programmers can be retained on a fee basis or as part of arrangements made with computer manufacturers or commercial computer service companies. Nearly every university having a computer provides short training courses from time to time on an introduction to computer program "languages".

(b) The student-request information is obtained from the registration cards. The student's registration card, recording the courses elected, and signed by the adviser, is transmitted to the Schedule Office where code

punched "card decks" are assembled to identify the student and the courses which he has elected. These "card decks" are prepared by the IBM 1401 computer here at the University of Massachusetts. The "decks" average between 8 and 9 cards for each student.

For courses which involve laboratory work, a student reuires two cards; for example, one for a lecture period and one for lab assignment. In addition, a separate card is required for periods to be kept available for extra-curricular activity as requested by the student. These, together with cards for military science requirements, physical education periods, and the class assignments mean that many students will have more cards in their "decks" than the number of courses they elect would indicate.

(c) Full course-and-section information must be provided on each of the total 1900 sections for the 700 courses offered in a semester. The course-and-section information must include the section identification number, the maximum number of students that may be assigned to it, and its meeting times and place. This information is given by the departments to the Schedule Office and code cards for this data are also prepared by the 1401.

(3) It would be possible to use these three sets of card inputs to schedule classes by computer. But for use in the actual scheduling operation on the 7090, all of the information on two of the three sets of cards is transferred to magnetic tape by the 1401 at the University. Card input to the 7090 computer is possible—that is, the information could be read directly by the 7090 from the cards instead of from magnetic tape. However, this method would take approximately five times as long as the faster tape input.

The information on 55,000 cards, representing the student-request information of 6200 students scheduled for this current semester, could be recorded on two magnetic tape reels. The information is actually distributed on four reels to reduce delays in the event of mechanical difficulty during the computer run.

The data on course-and-section information is put on another tape reel. However, the program of directions for the 7090 is card input. The entire problem is then run off on the 7090 in an hour and a quarter, including setup time.

(4) The students are assigned class schedules by the 7090 at the rate of approximately 1,000 every eight minutes, less than a half second per stu-

dent. These results are recorded on magnetic tape which is then brought back to the University's 1401 which then

(a) Prints the schedules for the individual students on cards which are given to the students, and

(b) Sorts the individual schedules to produce section rosters for use by the faculty.

(5) At registration, which is on the day preceding the first classes of the semester, the student receives his schedule. He may, if he wishes, make adjustments with the various departments at that time. This could involve a mere changing of sections within a course, or it could involve the dropping of one course and/or the addition of an alternate. In any event, this stage of the registration and scheduling operation is in the hands of the department. These changes as reported by the departments will be summarized by the Registrar and incorporated into the student's permanent record after about three weeks of the semester have passed when the majority of such changes have been accomplished.

WHY COMPUTER SCHEDULING?

The most important question in this matter of computer scheduling is why should it be adopted in the first place? What are its advantages?

The answers to these questions depend somewhat on whether it is the student, the faculty member, the department head or the administrator who asks them.

From the student's point of view, computer scheduling probably is unattractive, at least initially. He feels that he has lost all initiative in developing a study program and that he is the victim of impersonal automation. A critical analysis of the situation will prove that this reaction is unwarranted.

First, the student's previous opportunity to select his hour program was subject to revision by the Schedule Office when it acted to balance section sizes—to assure that all sections of Mathematics 1, for example, were of equal size (averaging 30) rather than having 50 students in one and only 10 in another.

Second, the student who has a justified need for a particular program can be assured of getting that program. Also, even without this attention to personal requests for a particular section, the junior and senior level courses normally have but one section and the computer has no alternatives in the assignment of a student.

It is primarily in the freshman and sophomore subjects that the large number of alternatives is possible. It is here also that the student is least

experienced in the selection of a sound program which is consistent with the University's needs and his own desires. One of the elements in the program is designed to develop a schedule for the student which is academically sound; that is, which spreads his classes throughout the week rather than concentrating them on certain days. A student cannot realize his full potential if he has to prepare for five courses on one day, and then be attentive in five lectures on the next day.

For the faculty member, who formerly had to spend appreciable time assisting students in the development of detailed hour plans, computer scheduling means more time available for the true purposes of counseling—i.e., the discussion with the student of his ultimate objectives and his courses for the next semester.

Human error in hand scheduling resulted commonly in a student reporting to a section other than that in which he was anticipated. The frustrating confusion incidental to these adjustments is eliminated by providing faculty members with class rosters which are accurately developed by the computer from the student assignment records. These rosters are also desirable to the faculty as they provide ready reference as to the size of the class and its composition by student major and student year in college.

For the department head, computer scheduling is desirable as it makes easy the development of sections whose sizes meet the particular needs of his classes for physical facilities (such as laboratory positions) or presentation considerations (large lecture or small recitation group). He also benefits from having available copies of the section rosters which he may use when analyzing the source of the demand for a course, or the desirability of accommodating a student by transferring from one section to another.

For the administrator, computer scheduling paves the way for increased utilization of the facilities of the University and makes more readily available the data from which future needs can be determined. Computer scheduling can match class size to room size, can provide analyses of section sizes for planning future classrooms, and can summarize demands for particular courses (how many students registered for the course, what majors were represented, what was the student's class in college). Particularly in instances where student demand taxes the available facilities (especially in laboratories), the ability of computer scheduling to match section size to room capacity insures maximum use of the available space.

GENERAL COMMENTS

The ultimate objective of computer scheduling is to produce combinations of teachers, students, times and rooms which provide the best education for the maximum number of students that can be accomplished with the human and physical facilities available. This must be accomplished with full regard for the reasonable needs of both faculty and students for schedules adjusted to personal requirements. It is to be emphasized that concentration is being given to develop a system that will deal with the individual as a human and not as a mere item on the assembly line.

For the present, only the assignment of student schedules has been achieved. For the present, the determination of the time and room for courses and the assignment of a teacher to the course must be continued as in the past, on the basis of experience and not a small amount of guess work.

Four years of planning and several full scale test runs went into the development of the present computer program. The full advantages which may be had are not fully known as yet. The first application was a success, but many areas were found in which the operation can be improved, greater information about student needs and departmental needs derived, and University potential better realized.

The computer cannot operate without humans to program for it, feed it information, operate it and use its output. But the computer can perform the mechanical operations dictated by the program and make the results available almost instantly. (The computer produces 2400 schedules in the time a human requires to do one, and the computer achieves more of the objectives desired from a sound scheduling program.) To meet the complexities of spiraling demands on the University, computer scheduling is a vital requirement. To attempt to solve today's problems today, the speed of the computer is a *sine qua non.*

AVAILABLE PUBLICATIONS

Information Series

No. 1—Parents' Ability to Meet College Costs at the University of Massachusetts, February 1962.

No. 2—Chapter 648, Acts of 1962—An act relative to the administration of the University granting certain powers of self-management.

No. 3—Chapter 787, Acts of 1962—An act establishing a medical school within the University of Massachusetts.

No. 4—Chapters 108 and 145, Acts of 1962—Resolve providing for a study relative to improving and extending educational facilities in the Commonwealth.

No. 5—Computer Class Scheduling: Experience at the University of Massachusetts, December 1962.

Miscellaneous Publications and Studies

Factors Involved in Considering Year Round Operation of Institutions of Higher Education, November 1961.

Justification of Salary Requests, UMass Budget for 1961-62, December 1961.

1962 Report of the Long Range Academic Planning Committee, submitted to the President and University Faculty, June 1962.

Digest of Recommendations Made in the 1962 Report of the LRAPC, October 1962.

Analysis of survey on allowable time for such things as consulting or contract research for which added compensation is received, at selected State and Land-Grant institutions, June 1962.

Distribution and Home Town Residence of Massachusetts Undergraduate Students enrolled at the University of Massachusetts, February 1962.

A Report on the University of Massachusetts and Its Relationship with the Commonwealth, prepared by the Faculty Committee on Trusteeship and Faculty Salaries, January 1962.

Comparative Tables of Application and Enrollment Data on Massachusetts Institutions of Public Higher Education (in Massachusetts) prepared by the Budget Bureau, C.A.F., April 1962.

Preliminary Enrollment Plans of Massachusetts Colleges and Universities, 1960-1975 (in process).

The above publications will be sent upon request at no cost while supplies last to other colleges and universities, bureaus of research, libraries, educational associations and similar organizations.